What is "inquiry"?

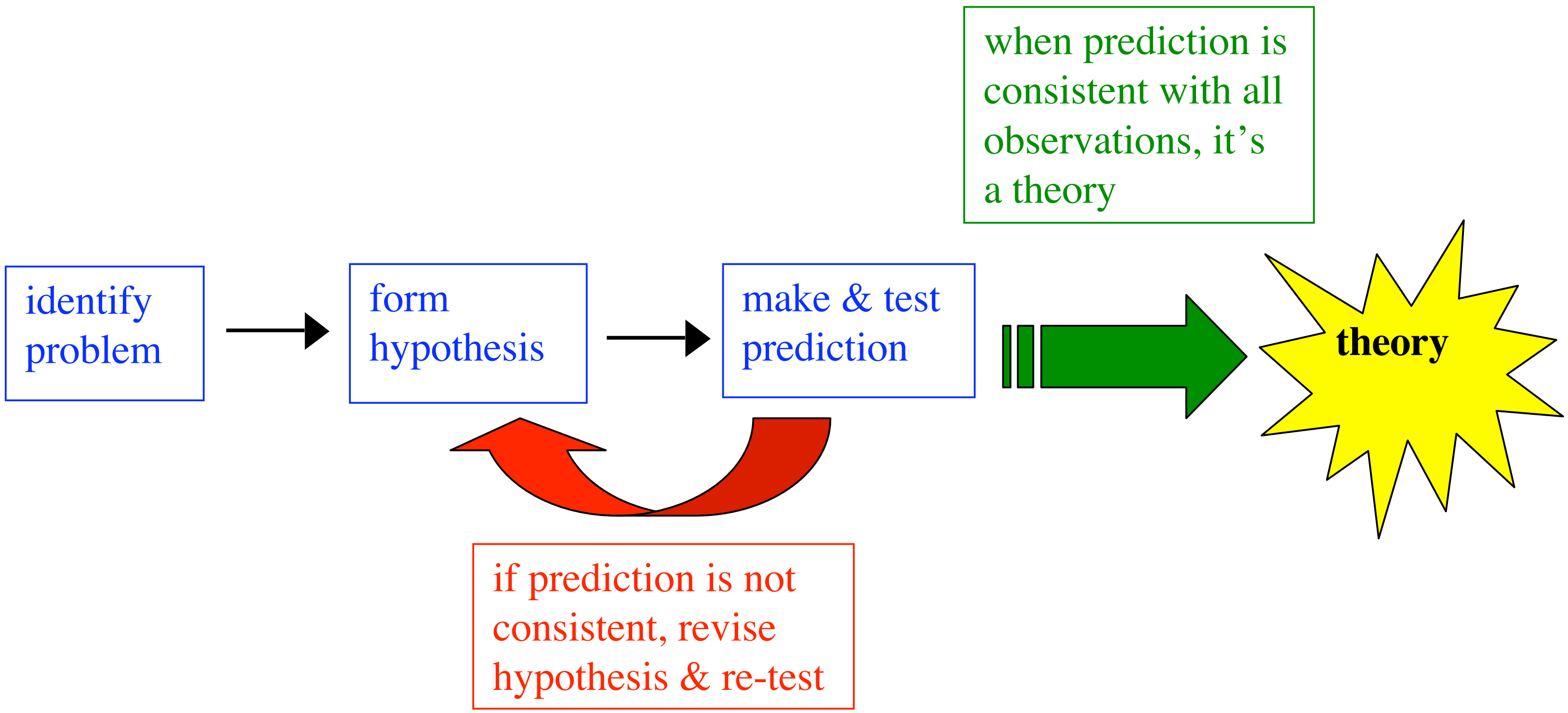
Why should students do inquiry?

excerpts from a workshop by Sandra Laursen, CIRES Outreach,
University of Colorado at Boulder

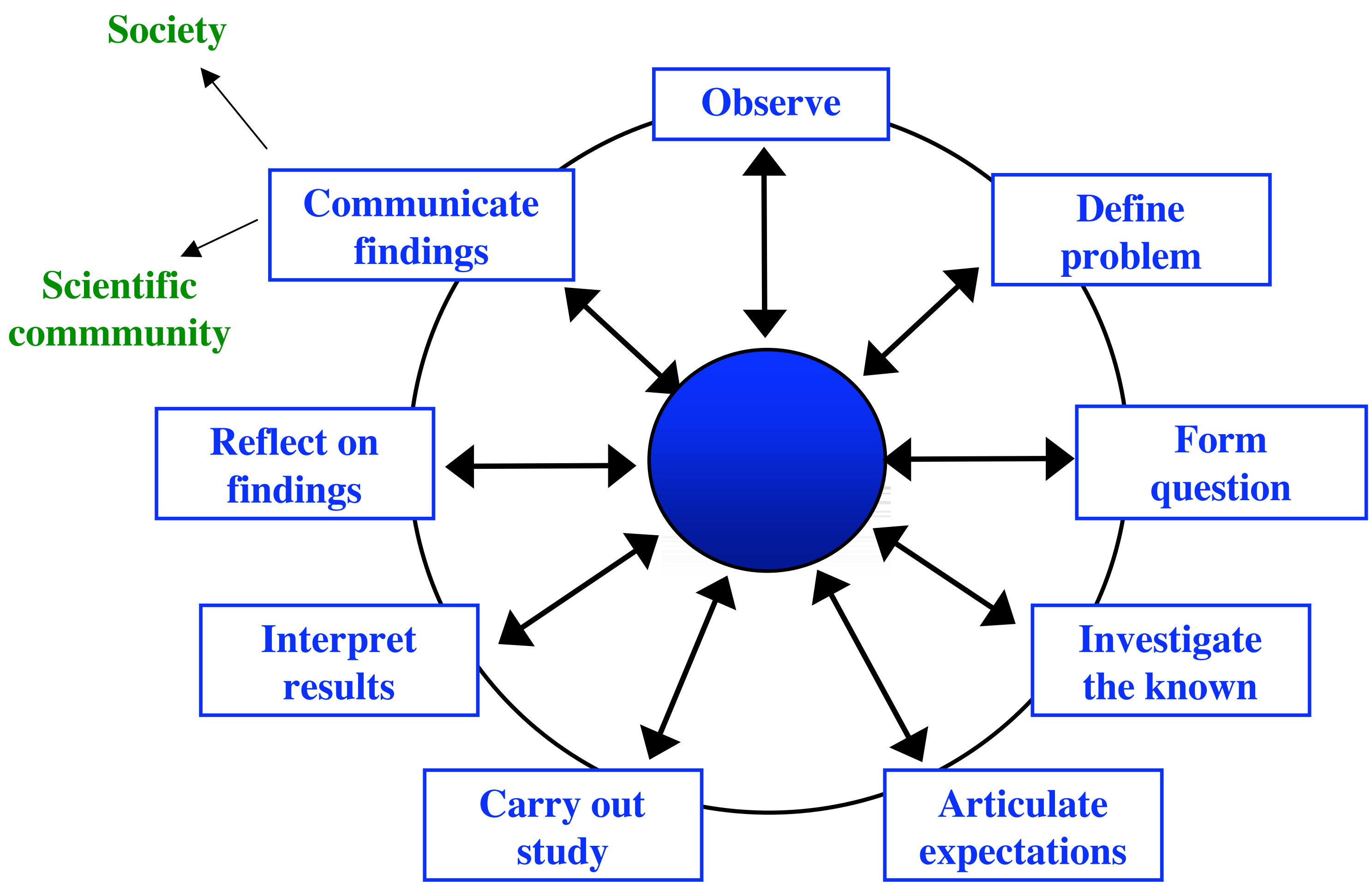
What do scientists do?

"Upward and Outward: Scientific Inquiry on the Tibetan Plateau"
http://cires.colorado.edu/education/k12/TibetOutwardUpward

“The” Scientific Method



The Inquiry Wheel



From "A Scientific Method Based on Research Scientists' Conceptions of Scientific Inquiry," R. Reiff, W. S. Harwood, T. Phillipson. Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science.

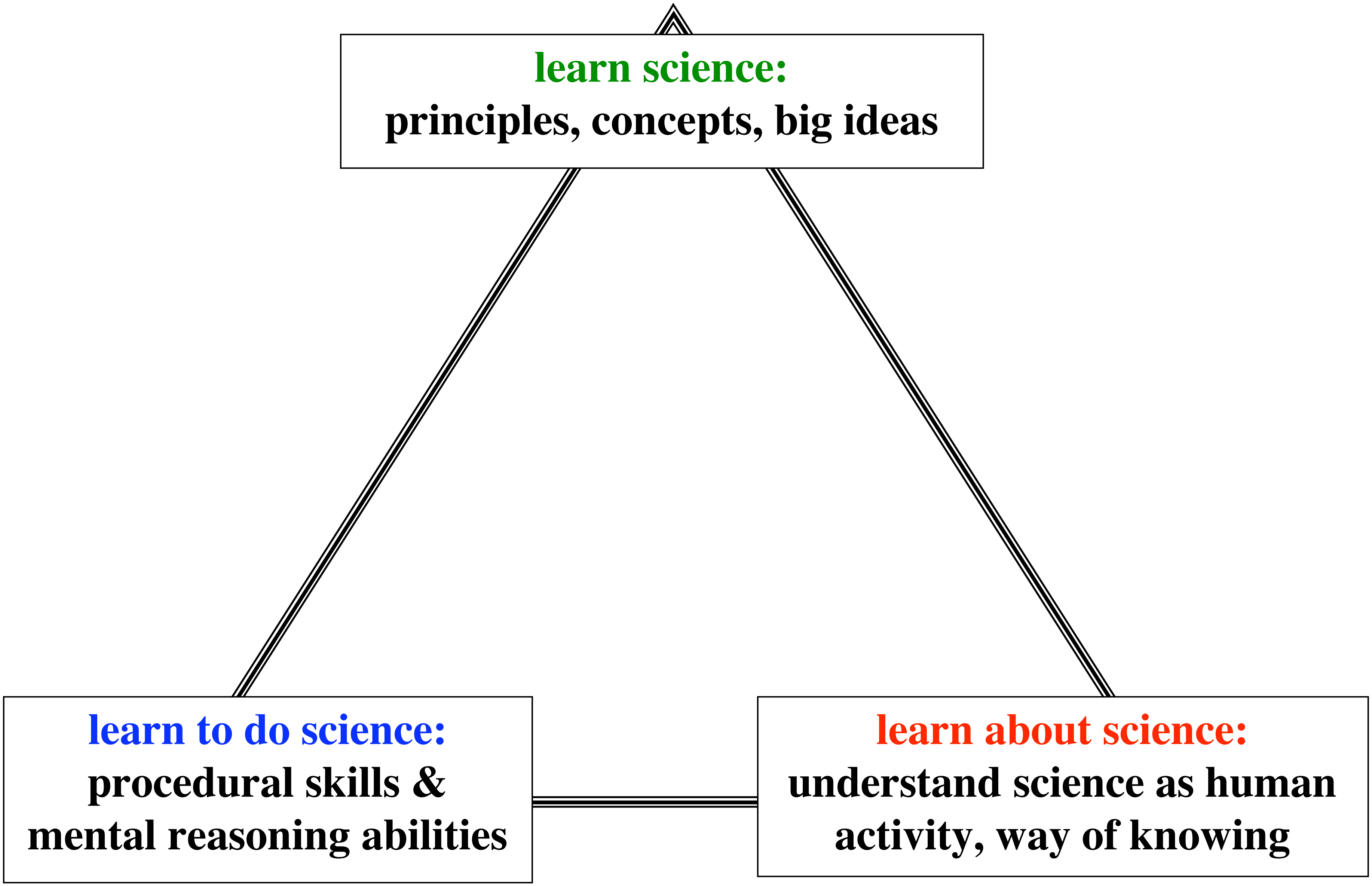
Inquiry as defined in the *National Science Education Standards* (NRC, 1995)

… a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations and predictions; and communicating the results.

Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

NSES Goals for All Students

- Learn the principles and concepts of science, the big ideas ("learn science")
- Be able to do science, the procedural skills & mental reasoning abilities needed to carry out an investigation ("learn to do science")
- Understand the nature of science as a human activity, a way of constructing knowledge ("learn about science")


learn science:
principles, concepts, big ideas
learn to do science:
procedural skills &
mental reasoning abilities
learn about science:
understand science as human
activity, way of knowing

National Science Education Standard for Inquiry: Abilities and Understandings

"Learning to do science"

Students should be able to…

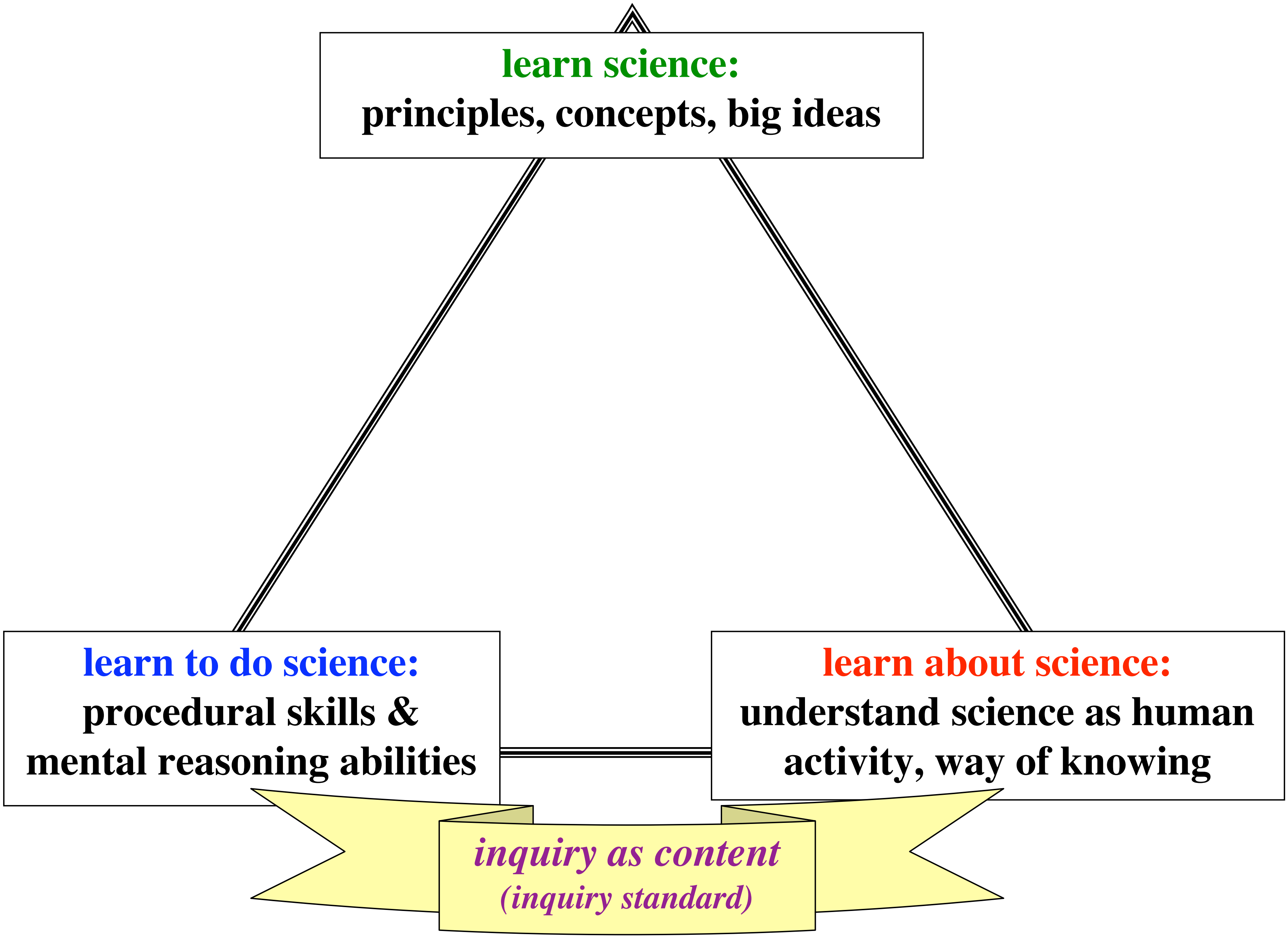
- Identify questions and concepts for investigation
- Design and conduct investigations
- Use technology and math to aid an investigation
- Formulate explanations using logic and evidence
- Analyze alternative explanations
- Communicate and defend an argument

"Learning about science"

Students should understand that in science …

- Investigations involve asking a question and comparing the answer to what is known
- Explanations emphasize evidence
- Explanations have logically consistent arguments
- Investigations are repeatable by others
- Scientists make their results public, review and ask each other questions

National Science Education Standards, NRC, 1995.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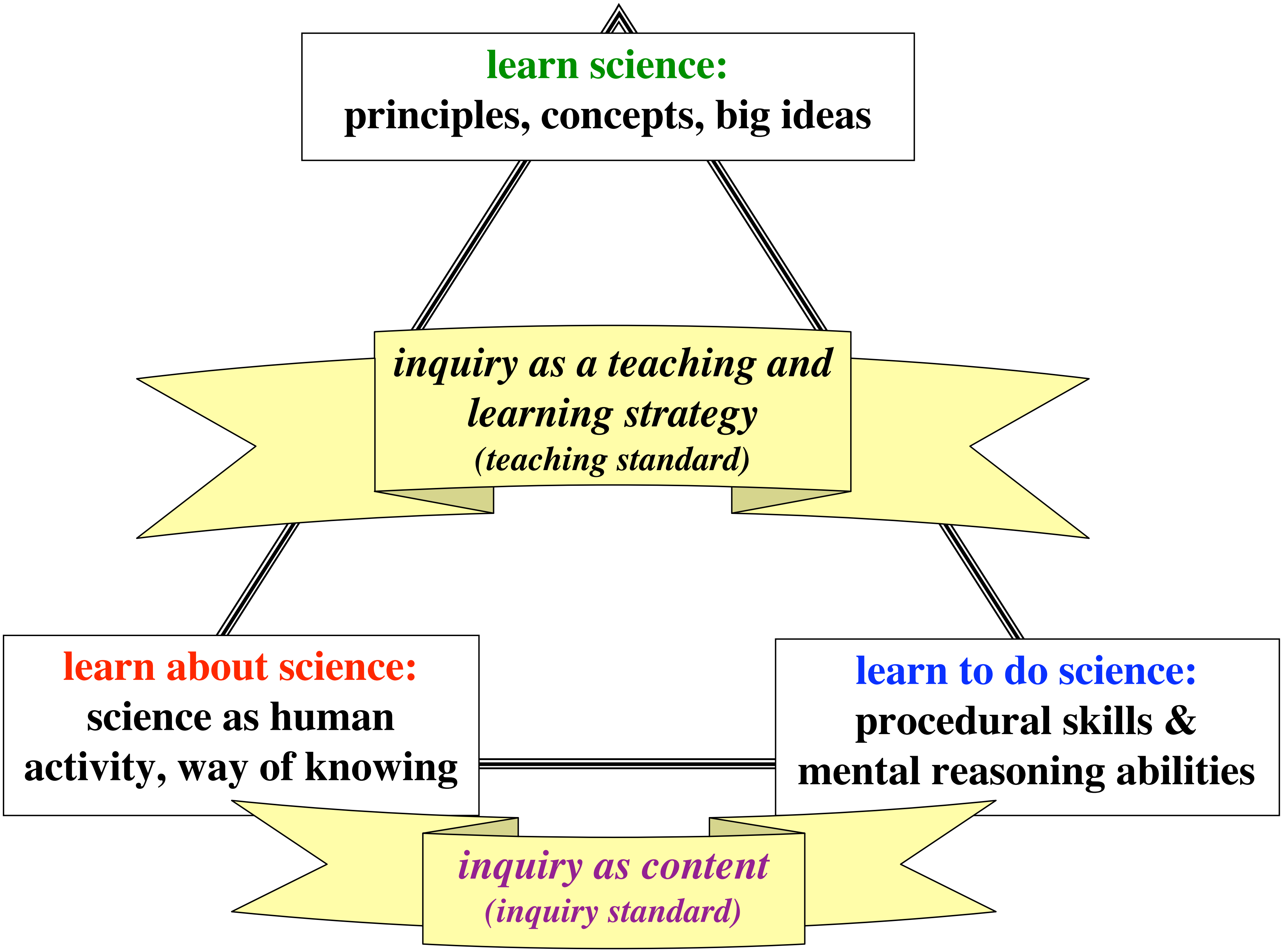
inquiry as content
(inquiry standard)

Classroom Inquiry as a Teaching and Learning Strategy

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.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inquiry as a teaching and learning strategy
(teaching standard)
learn about science:
science as human activity, way of knowing
learn to do science:
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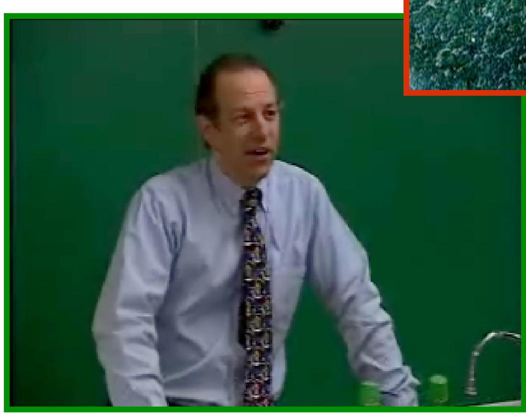
inquiry as content
(inquiry standard)

Goals for Today

- Advance understanding of inquiry as a current "best practice" in K-12 science education
- Share experiences highlighting three elements of inquiry: learning science through inquiry; learning the process of science doing inquiry; learning about the nature of science as inquiry
- Consider how to incorporate the essential elements of inquiry into classroom work
- Provoke thought and exchange ideas

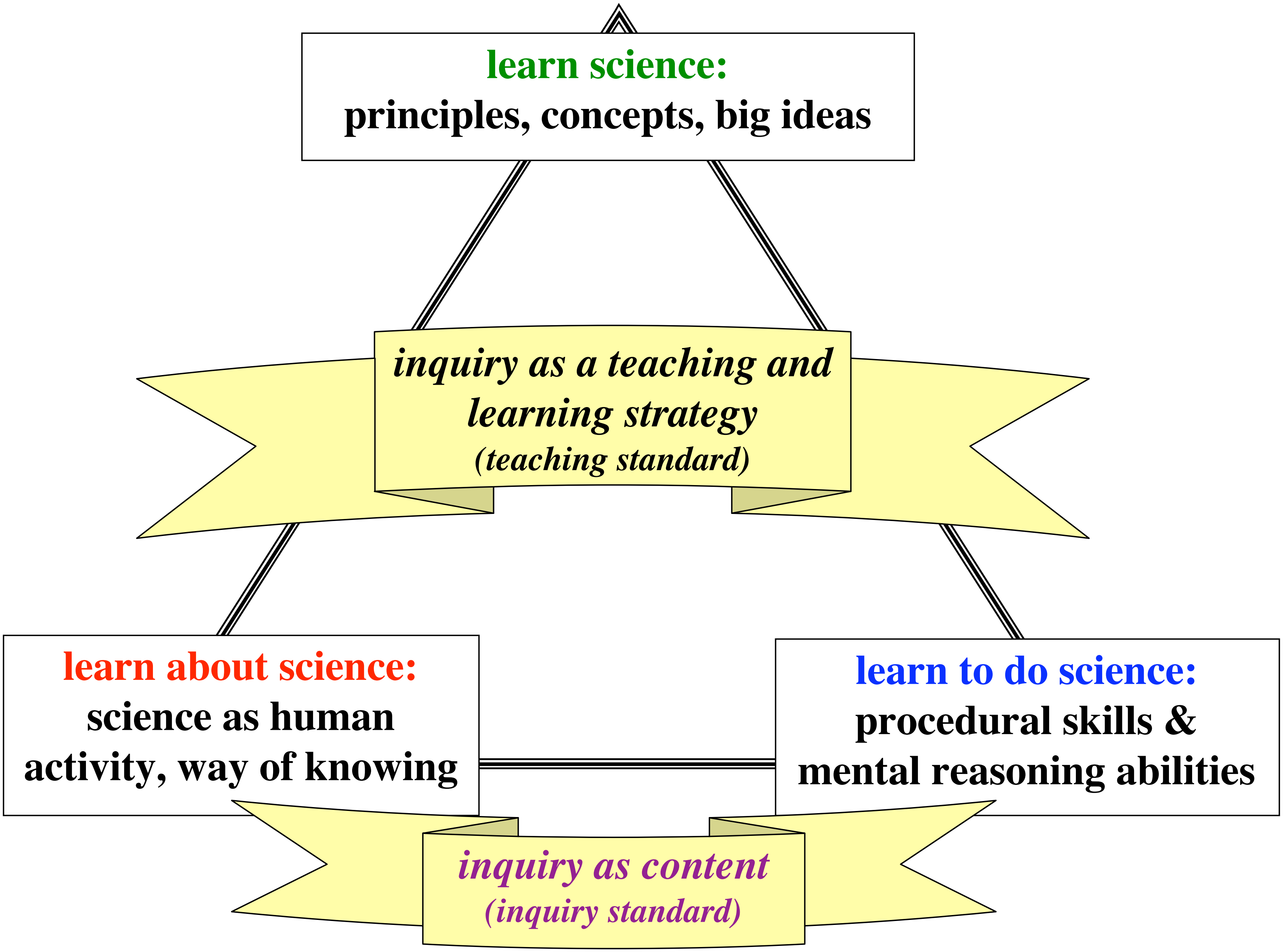
3 Experiences of Inquiry



- Abilities to do inquiry
- Understandings about inquiry
- Learning scientific concepts by doing inquiry

To be continued...

Sat- 8:30-12:30



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Essential Features of Classroom Inquiry and Their Variations

Essential Feature *V a r iations*

1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use to sharpen communication	Learner given steps and procedures for communication

More ----------------------------- Amount of Learner Self-Direction --------------------------------- Less
Less ---------------------- Amount of Direction from Teacher or Material ------------------------ More

from *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. NRC, National Academy Press: Washington, DC, 2000.

Group task: Three approaches to teaching about trees

Read one card aloud (any order), describing a K-4 lesson about trees.

For each approach to the lesson,

1. Identify some ideas that students would learn.
2. Relate each to one corner of the triangle:
   - Learning science (principles, big ideas)
   - Learning to do science (procedures & thinking)
   - Learning about science (nature of science)
3. What differences do you notice among the three approaches?

Tree tales from Morrow, “Misconceptions…” (2000), spacescience.org

Research Base on Learning

1. People build new knowledge and understanding based on what they already know and believe ("prior knowledge", "misconceptions").
2. Understanding science is not just knowing facts; people must organize and actively build them into a conceptual framework to be useful in new settings ("schemas", "constructivism").
3. People need to monitor and reflect on their own learning as they learn ("metacognition").

How People Learn, NRC 1999.

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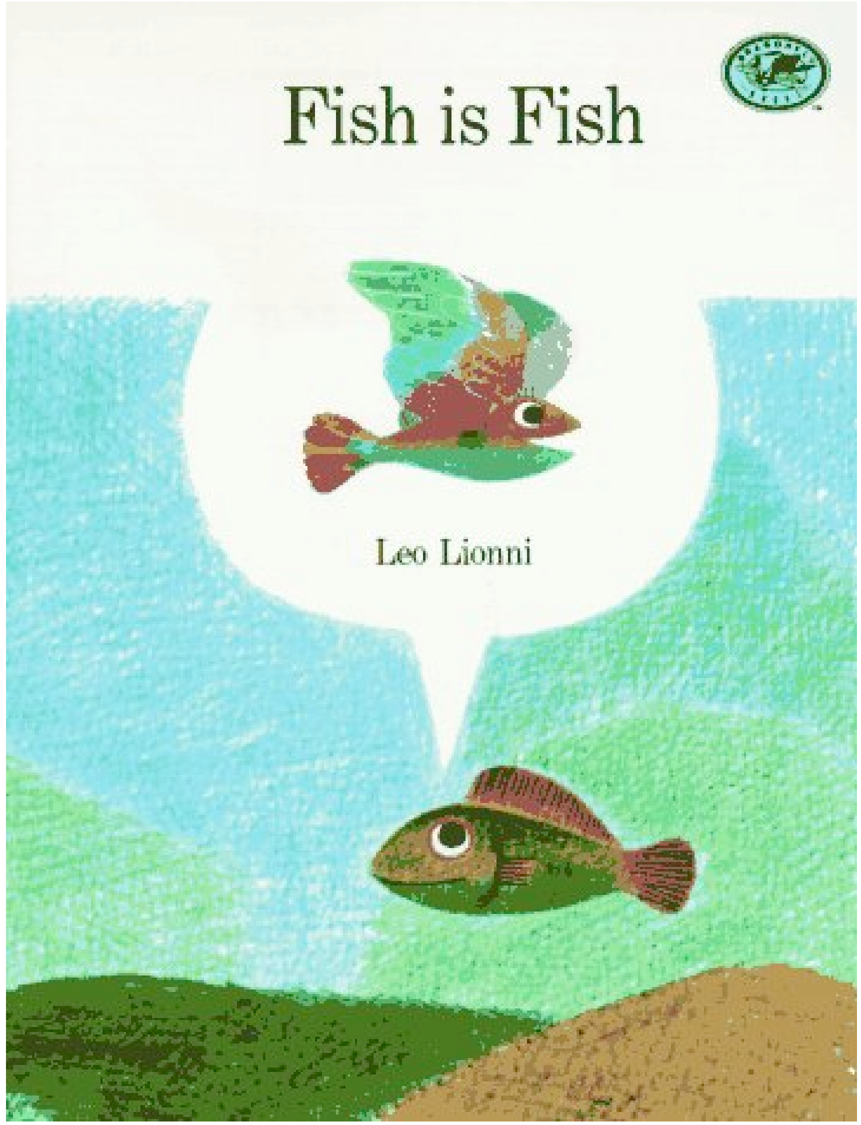
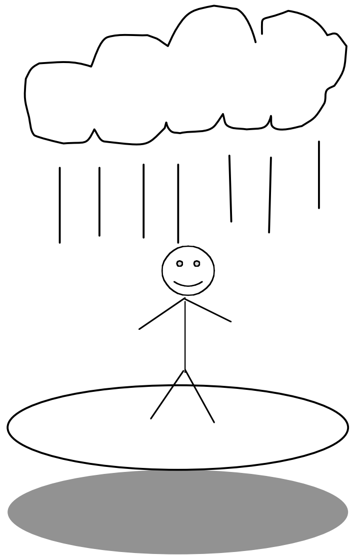
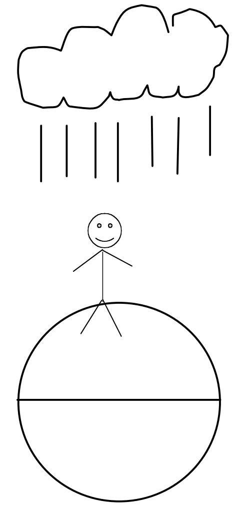

Fish is Fish
Leo Lionni

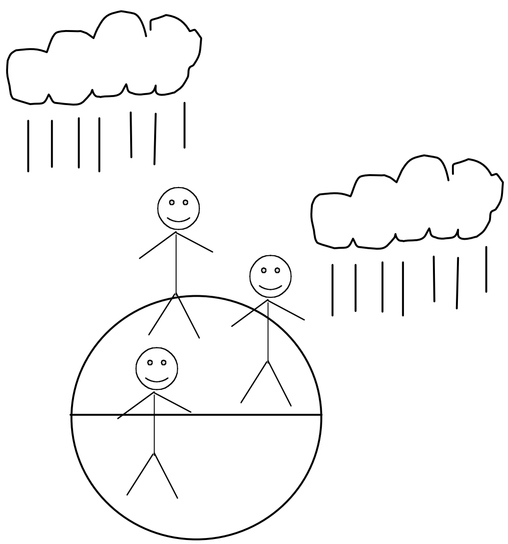
Earth is round.
Rain falls
'down.'



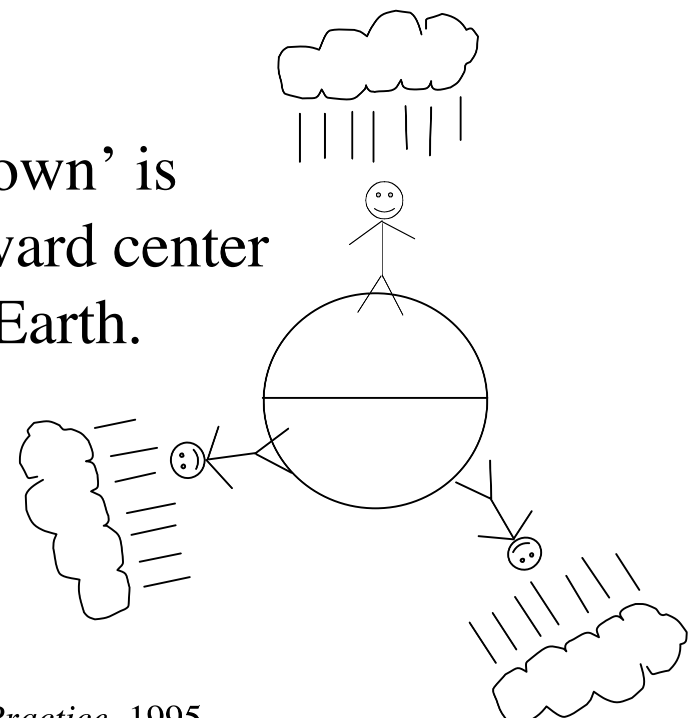
Earth is spherical.
People live only
on 'top' half.



People live
all over
sphere but
rain still
falls 'down.'



'Down' is
toward center
of Earth.



Baxter, Ch. 7 in *Learning Science in the Schools: Research Reforming Practice*, 1995

Strategies for Linking to Prior Knowledge

- Take time to call up and check on students' knowledge before you begin.
- Be aware of common misconceptions about your topic.
- Ask students to make a prediction.

Think of an example...

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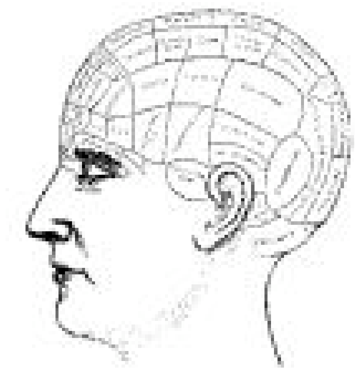
The Monotillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

1. What is traxoline?
2. Where is traxoline monotilled?
3. How is traxoline quaselled?
4. Why is traxoline important?

attributed to Judy Lanier

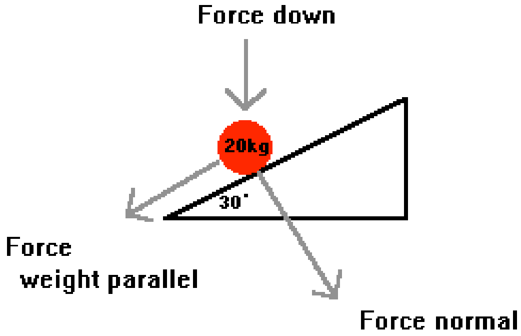
Mastery of facts is not necessarily understanding!



Ideas must be organized or "built" by the learner into a conceptual framework in order to be useful.

Students sort physics problems by superficial features.

Experts sort problems by concepts.



Strategies for helping concept-building

- Plan activities (hands-on, minds-on) rather than lectures.
- Have students predict-observe-explain a demo.
- Have students work in groups.
- Have students explain their ideas—write & talk.
- Help students relate ideas to existing knowledge
- Relate to students' knowledge from other grades & subjects; know how your curriculum aligns.
- Be a "guide on the side," not a "sage on the stage."

Think of an example...

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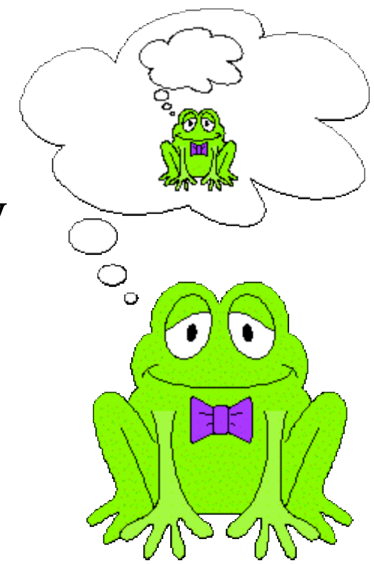
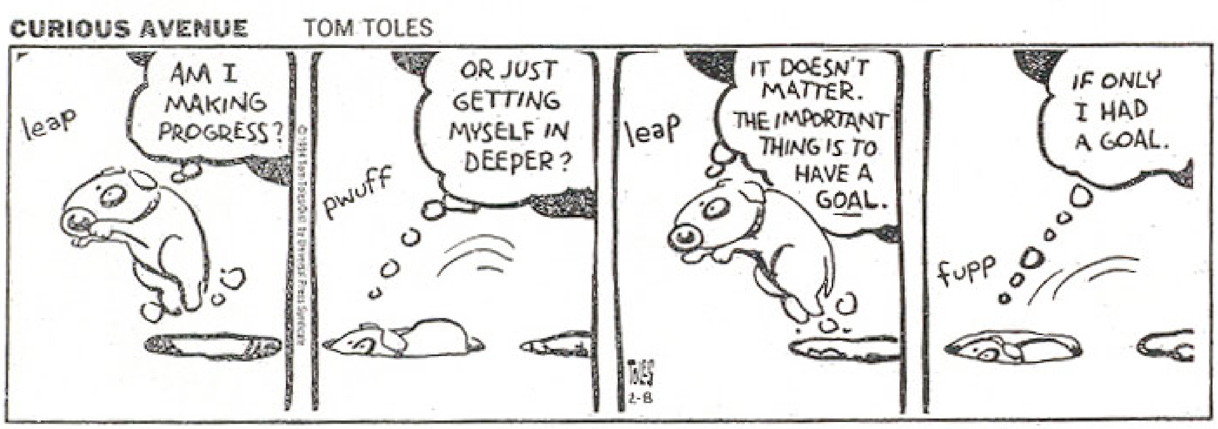
Metacognition: Thinking about thinking

1. Connecting new information to prior knowledge
2. Selecting thinking strategies deliberately
3. Planning, monitoring, and evaluating own thinking processes





Goal: learn how to learn, be able to apply past successful strategies to new problems

"Unless you know everything, what you need is thinking."
—Edward de Bono

NAEP Secondary Math Results (45,000 students)

Q. An army bus holds 36 soldiers. If 1128 soldiers are being bused to their training site, how many buses are needed?

70% got the correct long division result, 31 R 12

- 29% answered “31 remainder 12”
- 18% answered “31”
- 23% answered “32”

Students would not make the same mistake dividing up into cars in the parking lot!

Strategies for helping metacognition

- Ask: What do you know? What do you want to learn?
- Ask students to predict (decide what they think)
- Be explicit in modeling & teaching thinking strategies: how to proceed when you don't know, how to get info, check answers
- Debrief: What did you learn? What helped you learn? What did you try that didn't work?
- Help students relate ideas to existing knowledge, recognize & use ideas in new contexts

Think of an example...

Research supports inquiry learning: learning process parallels scientific process

- Examine prior knowledge
- Build up new concepts actively, work to fit them together
- Summarize, consolidate, reflect on the learning process

- Read literature, plan, review what's known, make predictions
- Investigate, question, experiment, revise
- Draw conclusions, consider alternatives, identify assumptions and uncertainties